Original Article

Comparison of the Tensile Bond Strength of Four Root Canal Sealers

S. Khedmat[1,2], M. Sedaghati[3]

[1] Associate Professor, Department of Endodontics, Faculty of Dentistry, Tehran University of Medical Science, Tehran, Iran
[2] Associate Professor, Dental Research Center, Tehran University of Medical Science, Tehran, Iran
[3] Dentist, Private practice, Tehran, Iran

Corresponding Author:
Dr M. H. Zarrabi, Department of Endodontics, Faculty of Dentistry, Tehran University of Medical Science, Ghods Street, Keshavarz Blvd, Tehran, Iran.
s_khdmt@yahoo.com

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Abstract:

Statement of problem: The bond strength of root canal sealers to gutta-percha seems to be an important property for maintaining the integrity of the apical seal which can result in reducing apical microleakage.

Purpose: The purpose of the present study was to compare the tensile bond strengths of four types of root canal sealers to gutta–percha. This study measured the maximum forces needed to disengage the bond between gutta–percha and these sealers.

Materials and Methods: in order to prepare the specimens, 40 blocks of unprepared gutta-percha (20×10×3mm) was used. Aluminum cylinders, 6 mm in diameter, were stabilized on the gutta–percha with small amounts of wax and were filled with one of the sealers. After setting each sealer, the drops of wax were removed and the tensile bond strengths of all the samples were measured using universal testing machine. Collected data were analyzed by ANOVA and Tukey tests.

Results: The highest bond strength was observed in the Diaket. It was followed by AH_{26} and Apexit. Dorifill had the least bond strength between the four groups. The tensile bond strength of Diaket and AH26 to gutta-percha were significantly higher than Dorifill and Apexit.

Conclusion: Th According to the findings of the present study it can be concluded that the use of Diaket and AH26 for root canal therapy may produce better results in endodontic treatments.

Key words: Sealer; Gutta–Percha; Tensile bond strength.

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INTRODUCTION

Obtaining a hermetic seal of the root canal system with an inert, biocompatible material is the main goal of a successful endodontic treatment [1]. The most commonly used core filling material is gutta–percha which does not spontaneously bond to dentin walls. Therefore in order to attain an ideal seal, gutta–percha should be used with a sealer [2]. In addition, adhesion of a root canal sealer to both gutta–percha and root dentin would be desirable in obtaining a hermetic seal that could prevent microbial microleakage [3].

In practice, the use of a solid core with a sealer leaves two interfaces along which leakage could occur; the core–sealer and dentin-sealer interfaces [4]. Hence if adhesion of sealers to gutta–percha and dentin were complete, apical leakage could not occur [5].

Grossman postulated that an ideal endodontic sealer should adhere firmly to both dentin and gutta–percha [6]. Differences in the adhesive properties of endodontic sealers may be expected because their interaction with gutta–percha can vary with their chemical composition.

In the last decades, the adhesion of endodontic sealers to gutta–percha and dentin has been the subject of several studies [3,5]. Jeffrey and Saunders [5] seem to have been the first investigators to build an appropriate model for this purpose; unfortunately, it was too complicated and difficult to duplicate.

According to Tagger [7] "bonding" is a better term as compared to "adhesion", because it implies that the attachment between the substances could have been commenced by other factors such as mechanical interlocking.

Bond strength is defined as the ability of two materials to adhere to each other [8]. Regarding to the type of forces which applied, usually two types of bond strength have been described; shear and tensile bond strength. Shear bond strength is the maximum stress at which the materials will fracture when one material is forced to slide along the other and tensile bond strength defines as the fracture of two materials occurring from stresses that pull them apart.

The bond between two materials is usually measured by applying tensile forces [9]. Therefore tensile bond strength was measured in the present study to compare the adhesive properties of different endodontic sealers to gutta-percha.

Four types of sealer have been introduced onto the market. Early sealers were modified zinc oxide-eugenol cements (e.g. Dorifill) based on Grossman's formulas and are by far the most popular and extensively used sealers. AH26 is an example of a resin-based sealer that has been used for many years despite the insolubility of the set material, making retreatment very difficult. The calcium hydroxide-based sealers (e.g. Apexit) were introduced in the 1980s, aiming to stimulate hard tissue formation for apical closure. The glass ionomer-based sealer (e.g. Diaket), the most recently introduced material, has been proposed as an endodontic sealer because of the natural bonding of the glass ionomer cement to radicular dentin [3,10].

The purpose of the present study was to measure and compare the tensile bond strength of these four types of endodontic sealers to gutta percha.

MATERIALS AND METHODS

Forty blocks of unprepared gutta–percha (Apadana Tak co., Tehran, Iran) measuring $20 \times 10 \times 3$mm were used in this experimental study. Aluminum cylinders with the 6 mm internal diameter and l0 mm height with 2mm holes in the upper part were stabilized to the gutta-percha with two drops of boxing wax. The endodontic sealers including Diaket (3M-ESPE, Seefeild, West Germany), AH26 (DENSPLY Detrey Gm bH, Germany), Apexit (Ivoclar – Vivadent, Schaan, Liechtenstein) and Dorifill (Dorident Co, Austria) were mixed according to the manufacturer's instructions and placed inside their respective aluminum cylinder. Pins were inserted into the holes of the cylinders. The specimens were placed in a humid area at 37°C for 48 hours to allow the sealers to set. After the setting time was over, the drops of boxing wax were removed because they might have influence on the final results.

All specimens were inspected for any defect and only flawless samples entered the experiment.

Finally, 10 specimens were tested for each group of sealers. Each sample was fixed to the universal testing machine (Zwick, 1494, Germany). At this point the tensile bond strength of the sealant to gutta-percha was measured at a cross-head speed of 1mm/min and using a 20kg load cell. The maximum load (gm.) at tensile failure divided by the cross–section of bonded area (28.26 mm^2) was expressed as tensile bond strength in MPa. The collected data were analyzed using one-way ANOVA and Tukey tests.

RESULT

The bond strength results are summarized in Table I. According to the results of the present investigation the highest bond strength was observed in the Diaket. It was followed by AH26 and Apexit. Dorifill had the least bond strength between the four groups (Fig. 1). One-way ANOVA revealed a statistically significant difference ($P<0.001$) among the tested materials.

Tukey's test separated the sealers into two groups, group one (AH26 and Diaket) and group two (Dorifill and Apexit). The sealers in the first group (AH26, Diaket) exhibited a significantly stronger bond to gutta–percha than the sealers in the second group (Apexit, Dorifill) ($P< 0.001$), but a statistically significant difference was not observed between the bond strengths of the sealers in each group.

In all tested specimens there was no cohesive failure. There were 7, 6, 4 and 3 adhesive–cohesive failures in the AH26, Diaket, Apexit and Dorifill groups respectively.

DISCUSSION

Most previous studies have investigated the ability of endodontic sealers to prevent apical leakage [4,10]. However, it has been shown that different leakage evaluation methods may exhibit different results on the same sealer. In addition, specification of the exact interface responsible for the leakage (dentin–sealer or gutta percha–sealer) is not possible when using leakage studies [3].

Considering the disadvantages of leakage studies and the fact that greater adhesion of sealers to gutta-percha can prevent apical leakage, the present study was designed to investigate the adhesive ability of four endodontic sealers to gutta-percha and to compare them by measuring their tensile bond strengths.

Some of the previous published methods for measuring the bonding of endodontic sealers to gutta–percha were impractical for use with large series of materials. For example, Orstavik et al [4] tested only 3 samples in each group of sealers. Wenneberg [11] attempted to duplicate clinical conditions by using a thin layer of sealer between disks of gutta-percha and bovine dentin. Although the model permitted calculation of the combined bonding strengths of the sealer to dentin and to gutta-percha, it could not disclose the exact value of the bond to each substrate. Furthermore, separation did not always occur at an interface, indicating the possibility of cohesive failure of the sealer. This information may be adequate at the clinical level, but it does not contribute sufficient data for the researcher in bio-

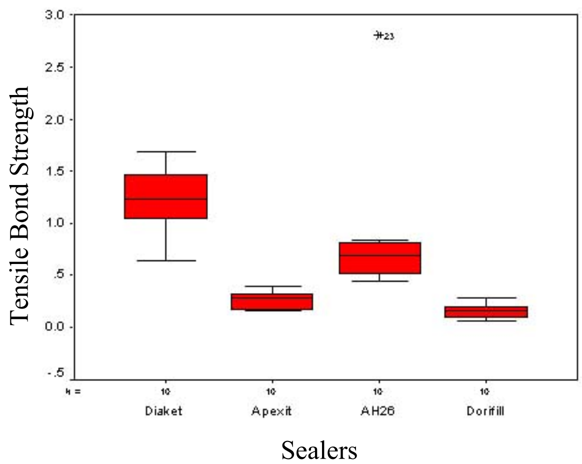

Fig.1: Box plot of tensile bond strength of different sealers to gutta-percha

Table I: Mean tensile bondstrength of endodontic sealers to gutta-percha (in MPa).

Sealer	Mean Tensile Bond Strength	SD*
Diaket	1.23430	0.338405
AH26	0.85810	0.699900
Apexit	0.25480	0.083830
Dorifill	0.14810	0.066666

*: Standard Deviation

materials, especially if one is looking for factors that may enhance or inhibit bonding. Pashley et al [12] concluded that tensile testing produced more uniform stressing than shear testing. According to this study, a reproducible method was used in the present investigation to measure the tensile bond strength of endodontic sealers to gutta-percha.

Tensile bond strengths of low magnitude, as encountered in bond strength studies are highly susceptible to transverse forces. Thus gutta-percha blocks, cylinders and hooks were placed in a straight position during mounting in the testing machine to avoid influences from transverse forces. Bond strength measurements of the two surfaces in the current study revealed that all tested sealers had measurable adhesive properties.

Diaket, a poly–vinyl resin, showed the highest bond strength of 1.23 (0.3) MPa to gutta–percha which is comparable with similar investigations [4,11]. In a study conducted by Orstavik [4], the tensile bond strength of Diaket to gutta-percha was reported as 1 Mpa and Wenneberg [11] in a similar investigation, found it to be 1.5 MPa. The adhesive properties of Diaket are acceptable, but because of its short working-time and tackiness, it is hard to manipulate [13].

AH26 is a resin based sealer that showed a relatively high mean bond strength of 0.85 (0.6) MPa to gutta–percha in the present study. Lee et al [3] also reported high bond strength for this sealer to gutta–percha (2.93 Mpa). Variations in measuring techniques may in part be responsible for the different tensile bond strengths obtained in numerous studies. Lee et al [3] used roughened gutta–percha; however, Jeffery and Saunders [5] showed that using roughened gutta–percha can enhance the bond strength of sealers to gutta–percha. Therefore it can be concluded that the higher value reported by Lee et al [3] may be because of the roughened gutta–percha, utilized in their study in contrast to the smooth surface employed in the current investigation. The high bond strength (5.7 MPa) of AH26 obtained by Tagger et al [14] may be due to the fact that they evaluated shear bond strength instead of tensile bond strength. It has been shown that shear bond strength usually demonstrates higher values as compared to tensile bond strength [8].

Apexit, a calcium hydroxide based sealer, revealed significantly lower mean bond strength (0.25 MPa) to gutta–percha than AH26 and Diaket. Tagger et al [14] studied the bond strength of endodontic sealers to gutta-percha, and found the shear bond strength of Apexit to be 0.503 Mpa. Considering the shear bond strength exhibits higher values than tensile strength, their results can be regarded as similar to findings of this study. Lee et al, [3] reported a mean value of 0.22 Mpa shear bond strength for another calcium hydroxide-based sealer (Sealapex), which was similar to the values obtained in the present study.

Dorifill is a zinc oxide–eugenol based sealer that exhibited very low bond strength (0.014 MPa) to gutta–percha in the present study, which is consistent with previous investigations [3,14]. Also Maccomb and Smith [15] reported that zinc oxide–eugenol sealers displayed no adhesive properties.

Evaluation of mode of failure revealed no cohesive breakdown within either cgutta-percha or cements. The mixed failures showed that the real tensile bond strength was a little higher than that obtained during the study [3].

CONCLUSION

The bond strength of Diaket and AH26 to gutta-percha was higher than Dorifill and Apexit. It is clear that adhesive strength is only one consideration in the selection of endo-dontic sealers. However, according to the findings of the present study, Diaket and AH26 produced higher bond strength than Apexit and Dorifill. Therefore the use of these sealers for root canal therapy might produce better results in endodontic treatments.

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